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GB A 2069127	GB 1354239	GB 0749785
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GB 1534603	GB 1226089	US 3929285

(58) Field of search
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(54) Fluid control valves and air treatment systems

(57) A fluid control valve comprising means defining a flow path for fluid (16), a variable flow restrictor in said flow path comprising a wall member (5) bounding a portion of said flowpath, and having flow passages (19) therethrough, means (20) for at least substantially closing a portion of said wall member against fluid flow therethrough, means (6) for producing relative movement between said wall member and said closure means to vary the area of said wall member exposed for fluid flow therethrough, the size of the flow passages through said wall member being such that there is at least one inlet pressure at which the valve with at least a substantial portion of the wall member exposed for fluid flow will produce a pressure drop substantially equivalent to the inlet pressure.

Preferably, said valve will produce said pressure drop at inlet pressure above 498 Pa (2 inches water gauge).

In Figs. 1 and 2, a perforate tube 5 reciprocates in a conduit 16. In Fig. 4, a shutter 40 with an aperture 41 rotates within a partially perforated member 37. The valve is located in an inlet for treated air forming part of an air distribution terminal 12 of an air treatment system.

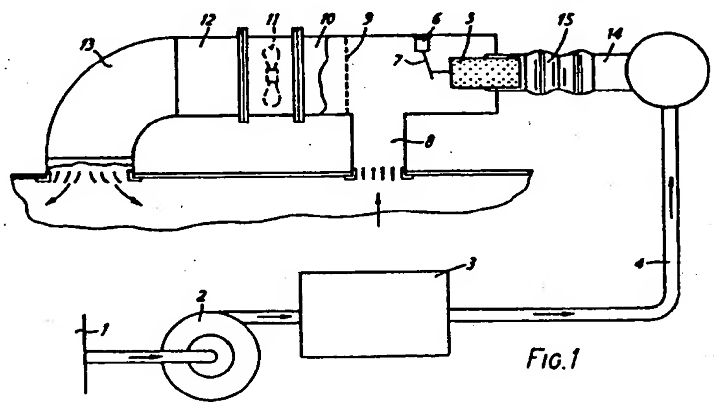
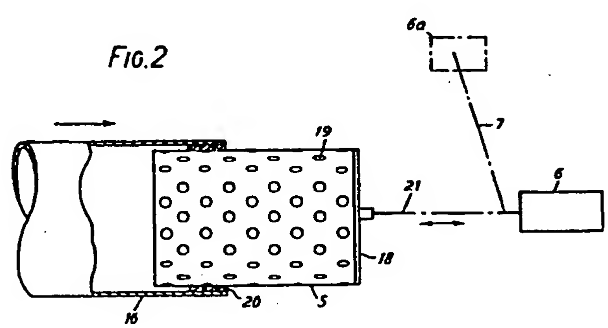


FIG.1

FIG.2



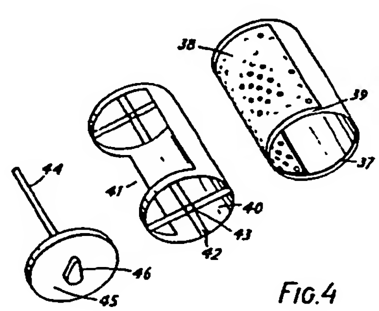


FIG.4

The drawing(s) originally filed was/were informal and the print here reproduced is taken from a later filed formal copy.

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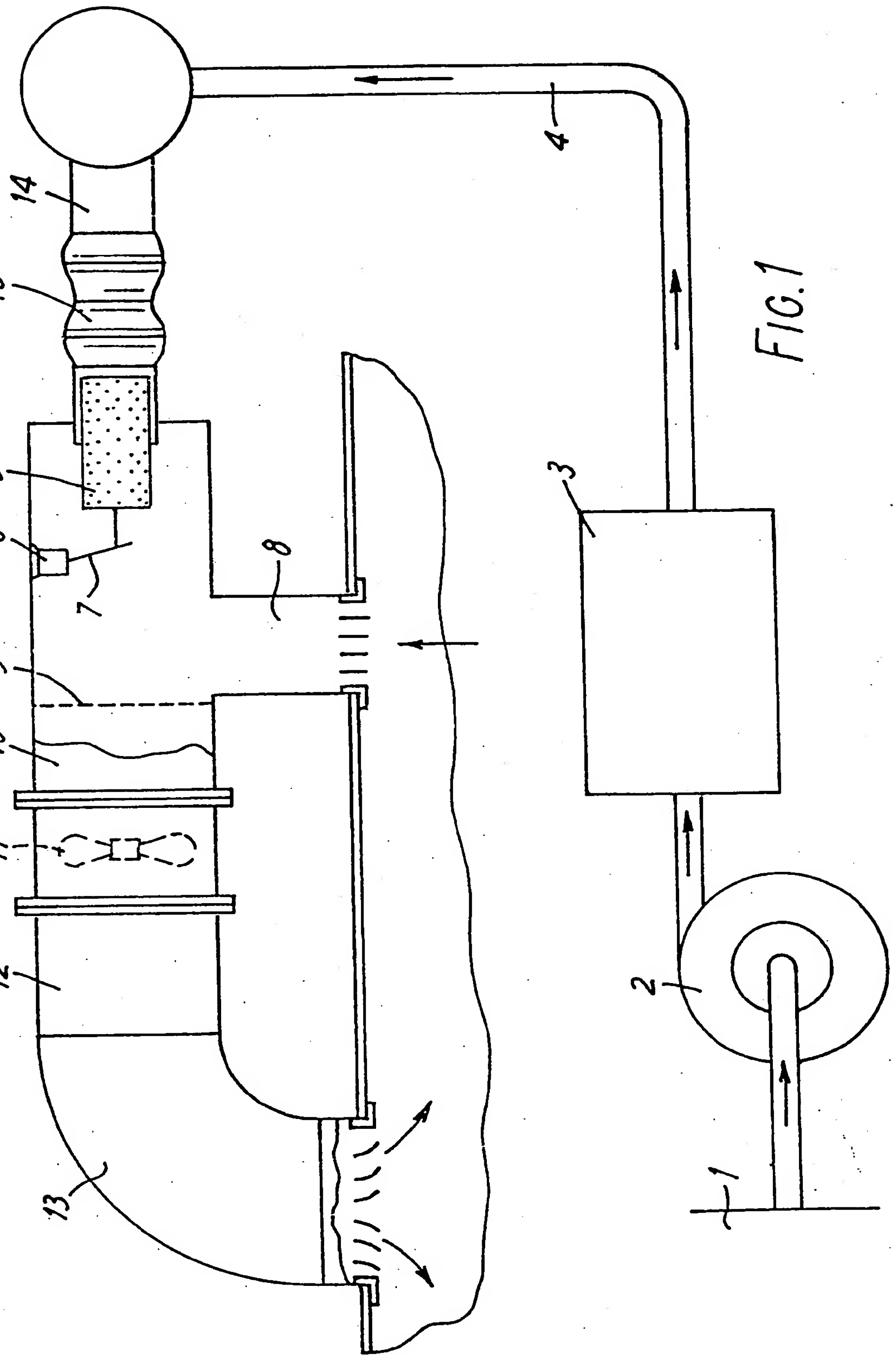

FIG.1

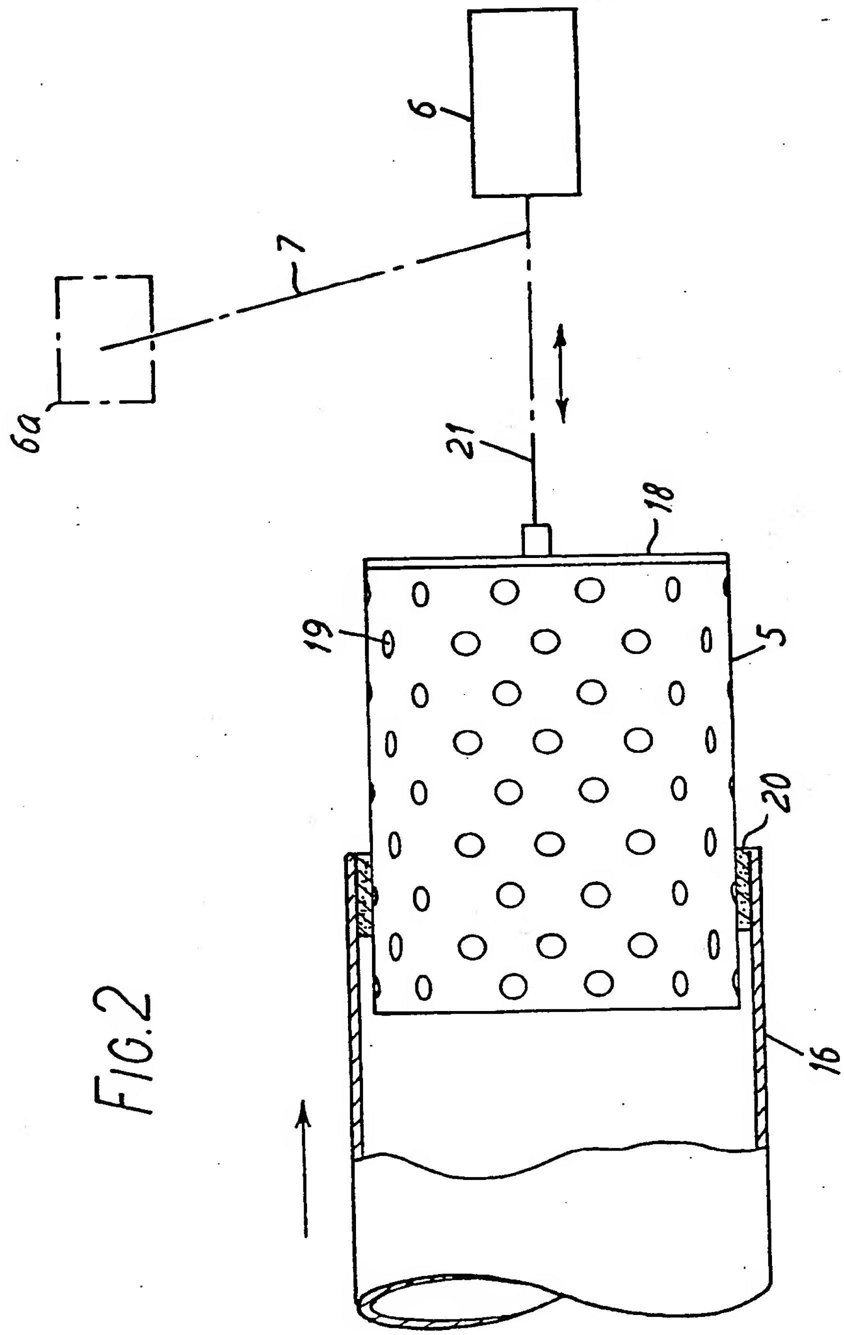

FIG. 2

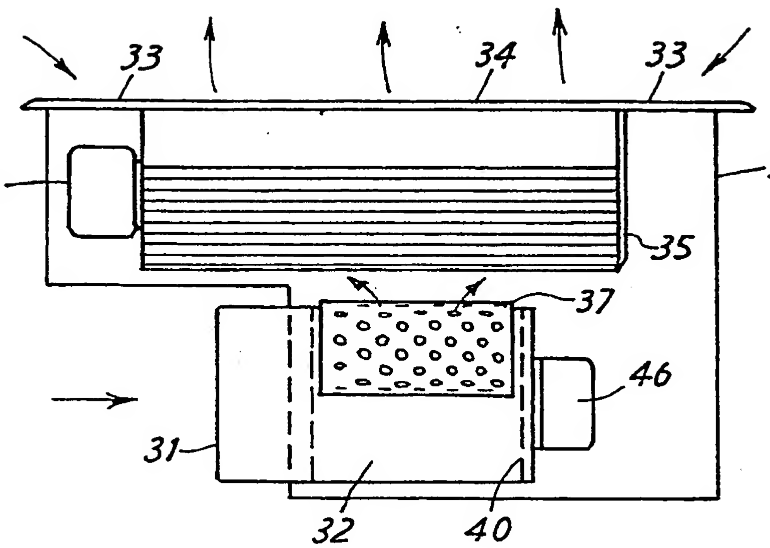

FIG. 3

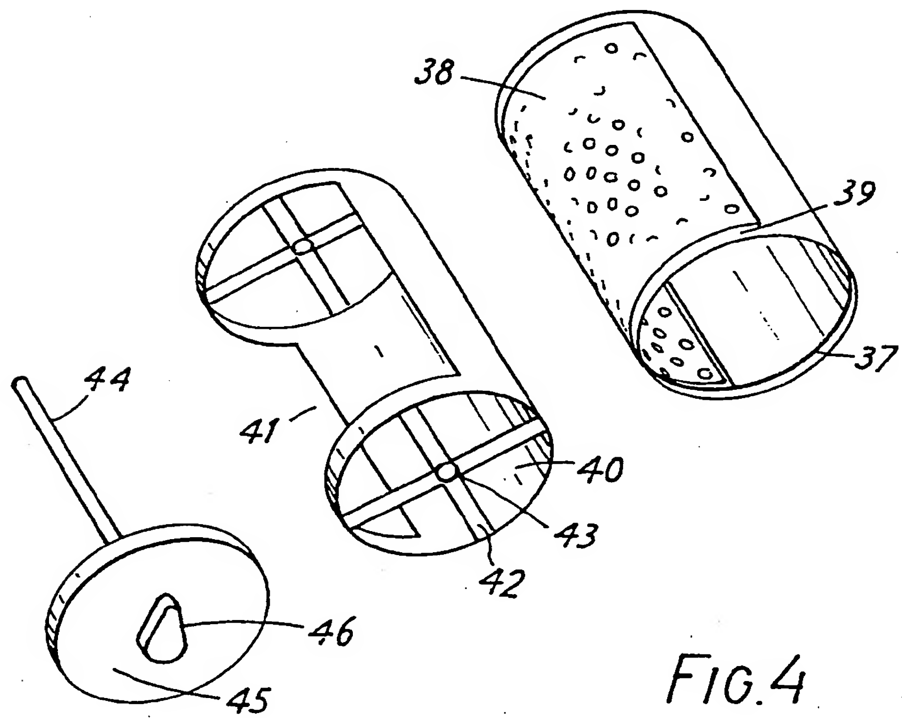

FIG. 4

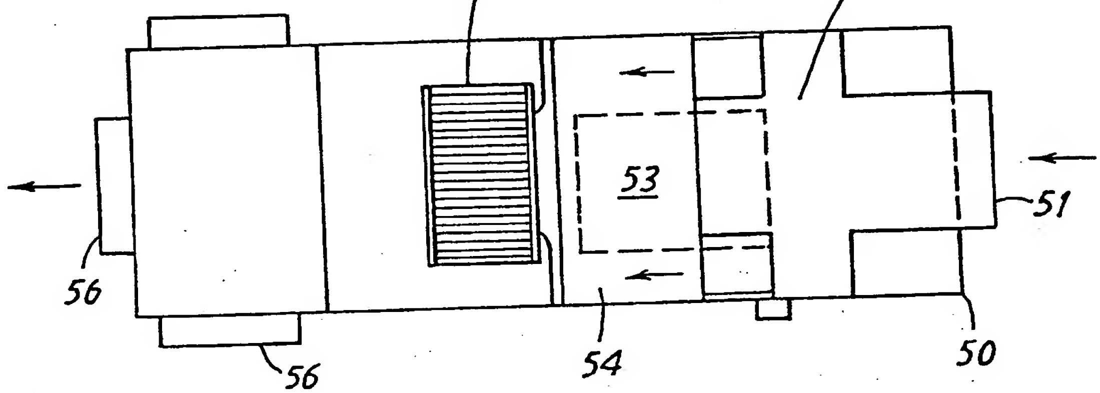

FIG.5

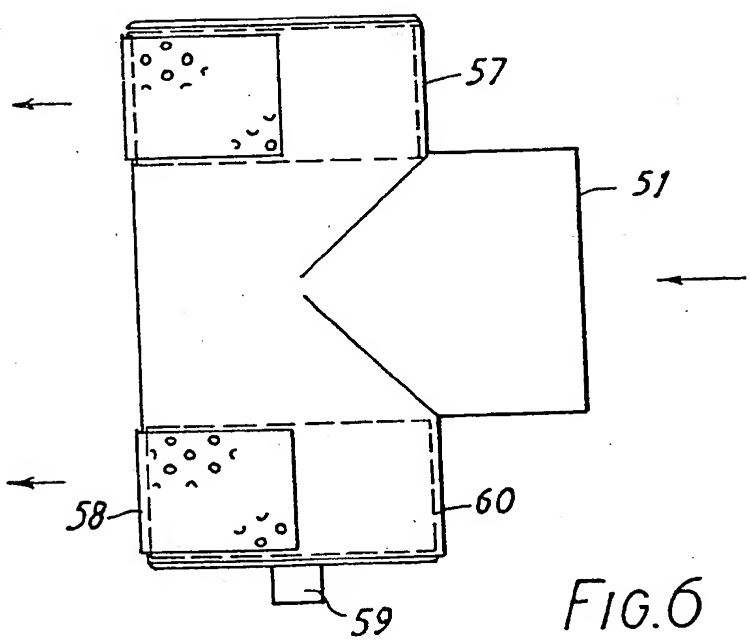

FIG.6

SPECIFICATION

Fluid control valves and air treatment systems

The present invention relates to fluid control valves and air distribution terminals and air treatment systems incorporating such valves.

Air treatment systems are known in which air is heated centrally and is distributed through ducts to points of utilisation distributed around the volume to be heated, typically in separate rooms of a building or in different parts of rooms of a building.

Commonly such air ducts are of large cross-sectional area so that adequate masses of air can be distributed through them and discharged into the space to be heated at an acceptably low velocity. It is also known to distribute the heated air through ducts of smaller cross-sectional area. It is then necessary to move the air at a higher linear velocity through these ducts in order to transfer air at a high mass rate to convey the quantity of heat involved at times of maximum demand.

In such a system, the delivery of heated air into the space to be heated can cause an unacceptable amount of turbulence and of noise in the heated space and it is known therefore to reduce these effects by causing the high velocity air to induce a secondary flow of air, air being drawn from the space to be heated and delivered back into the space mixed with the high velocity heated air, or primary air as it might be called from the heating source. An example of such a system is described in U.K. Patent No. 1316887.

It is also known to produce a flow of ambient air from the space in which the air is to be treated into an air distribution terminal and back into the space by using an air blower in the terminal to produce said flow. Typically the air blower produces a constant rate of output. Treated air, or primary air, is supplied to the air distribution terminal and is mixed with the air drawn into the terminal by the blower. The mixture of treated air and ambient air is then blown out by the blower from the distribution terminal. Various methods have been proposed for controlling the flow of air from the air ducts into such distribution terminals. In United States patent 3929285 of Daugherty Jr. the air duct for transport of heated air terminates in the distribution terminal in a reduced diameter portion described as a venturi restriction. A ball valve is mounted in the air duct adjacent the venturi restriction and is movable axially in the duct to approach and recede from the restriction under the control of an actuator linked to a thermostat. The ball is also spring loaded and is displacable in the axial direction to a limited extent by pressure in the duct.

Such a flow control system has a number of severe disadvantages. The range of movement of the ball serving to provide any significant alteration in the outflow of air from the duct is very small and the ball acts essentially to provide only open and closed states of the air duct rather than to provide genuine progressive alteration of the flow of air out of the duct. Moreover, as the ball approaches the venturi restriction, the progressively restricted flow of air will become turbulent and noisy due to the increasingly high velocity of the air passing over the ball and through the restriction. To attempt to cope with this Daugherty provides a noise absorbing baffle but this will not in practice prove an adequate solution to the problem.

Other systems suffering similar disadvantages have been proposed. Some use a control valve of the butterfly type, another uses a control valve having a ported cylinder at the outlet of the primary air conduit and a piston axially movable to open and close the ports.

When fully open such valves allow air to pass through at high velocity with little pressure drop. Until such control valves are almost shut, the pressure drop across them is considerably less than the pressure typically available in the primary air circuit for driving air through the valves. Therefore, little or no restriction of the flow occurs until such valves are close to closing and hence poor control is achieved.

In British patent No. 2069127 (Simmons) a system for treating environmental air is described in which treated air is conveyed between small diameter ducts to air distribution terminals where it is released into a buffer zone of enlarged diameter and passes from the buffer zone through a flow restricting perforated plate and is then mixed with air drawn into the distribution terminal by an air blower which expells the mixed air from the terminal. Such a system is quiet and efficient in use. In setting up a system of this kind with a number of terminals the effective open cross-sectional area of the perforate plate for each terminal needs to be selected with care in order that the system may be properly balanced. Once the system is balanced, it will operate efficiently but it is not easy to modify the system by adding further terminals because that is likely to upset the balance of the system and necessitate a recalculation of the effective open cross-sectional area required in each of the terminals.

It might be thought that a terminal design such as Daugherty teaches might solve this problem in that Daugherty professes to provide a continuous control of the effective cross-sectional area of the exit from the duct for treated air into the distribution terminal. However, in practice, as pointed out above, Daugherty's control mechanism will not provide a satisfactory variable control over the flow of treated air into the terminal as the ball and restriction mechanism taught by Dau-

gherty acts to provide to sharp a cut off of air flow in response to linear movement of the ball.

However, Daugherty neither suggests or describes the use of the ball and venturi restriction appearing in the terminals he describes as a means of balancing an air treatment system.

The systems described above are applicable not only to the distribution of heated air but also primary air treated in other ways, e.g. by cooling.

The present invention provides a fluid control valve comprising means defining a flow path for fluid, a variable flow restrictor in said flow path comprising a wall member bounding a portion of said flowpath, and having flow passages therethrough, means for at least substantially closing a portion of said wall member against fluid flow therethrough, means for producing relative movement between said wall member and said closure means to vary the area of said wall member exposed for fluid flow therethrough, the size of the flow passages through said wall member being such that there is at least one inlet pressure at which the valve with at least a substantial portion of the wall member exposed for fluid flow will produce a pressure drop substantially equivalent to the inlet pressure.

Preferably, the valve will produce said pressure drop at inlet pressures above 1495 Pa (6 inches water gauge).

Preferably, said valve will produce said pressure drop at inlet pressures above 498 Pa (2 inches water gauge). For some applications, it may be desirable that the valve will produce said pressure drop at inlet pressures above 62 Pa (0.25 inches water gauge).

Generally, the larger the apertures, perforations or foraminae in the wall member, the higher the minimum pressure at which the valve will exhibit the characteristic of providing a pressure drop similar or identical to the inlet pressure will be.

We have found that for dealing with high pressure systems in which the static pressure in the primary air distribution circuit is above 1495 Pa, circular perforations in the wall member of a diameter of 0.95cm (3/8 inches) are as large as will provide the desired result. Preferably, therefore, the apertures are in the range of 9.5 mm to 1.6 mm diameter. More preferably therefore the diameter of such circular perforations in the wall member is in the range of 0.44 to 0.51cm.

If non-circular, the apertures preferably have a largest dimension in this range or an area equivalent to a circle with a diameter in that range.

The perforations in the wall member need ot be circular. More generally therefore it is preferred that the flow passages through the wall member each have a cross sectional area not exceeding 0.7 sq.cm., more preferably not exceeding 0.16 sq. cm. For use in systems where the primary air static pressure is relatively low, even smaller flow passages may be desired.

The form of the wall member and the manner in which it interacts with the means for closing a portion of the wall member against fluid flow may be of various kinds.

In one arrangement, the valve is as described above, and the wall member is a foraminous or perforate tube telescopically movable to extend from an outlet of the said flow path by a greater or lesser extent, said tube having a closure of flow restriction downstream of said outlet, eg. at the end of the tube. Preferably, the tube is uniformally foraminous or perforate along its length, so that the effective outlet cross sectional area is directly proportional to the length of the foraminous or perforate tube extending from the outlet.

Preferably the valve further comprises actuator means adapted to move the tube telescopically in the outlet by a degree dependent on a signal provided to the actuator means. The means for generating a signal to cause the actuator to move the tube telescopically in the outlet which is preferably provided may for instance be a manual control such as a manually operable switch or may be some means for monitoring some ambient condition and moving the tube in response to variations in that condition, for instance a thermostat.

Another alternative arrangement, the valve may be generally as described above and the wall member may have a first portion having said flow passages and a second portion without said flow passages, and the closure may be a shutter having an aperture therein and the wall member and the shutter may be mounted to be adjacent and rotatable with respect to one another so as to vary the amount of said first and second portions of the wall member aligned with the aperture in the shutter.

Preferably, the wall member and shutter are interfitting generally cyclindrical members. Alternatively, they might for instance be overlying circular members.

Preferably, the wall member is disposed over the shutter. However, the shutter may lie over the wall member.

Preferably, the valve further comprises actuator means adapted to rotate the wall member and shutter with respect to one another. Preferably, the valve further comprises means for generating a signal to cause said actuator to rotate said wall member and actuator with respect to one another. In this type of embodiment also, the signal generating means may be a thermostat or a manually operable switch or other control.

The invention includes an air distribution terminal comprising a housing having at least one inlet for drawing in ambient air, at least one outlet for expelling air from the housing, and

an inlet for treated air, said treated air inlet being provided with a valve as described above.

Preferably the terminal includes an air blower for expelling air from the housing through the outlet or outlets.

Preferably the housing has a cross-sectional area substantially in excess of the cross-sectional area of the flow path of the valve.

The invention further provides an air treatment system comprising a plurality of terminals as described above, air treatment apparatus including means for drawing in and treating air, and means for delivering treated air from said air treatment apparatus to the flow path of the flow control valve of each said terminal. The means for treating air may suitably be means for heating or cooling or humidifying the air or a mixture of two or more of these functions.

Preferably the means for delivering treated air is a system of conduits of a cross-sectional area substantially less than the cross-sectional area of the housing of each terminal, preferably similar to the cross-sectional area of said flow path of the valve.

Preferably the system of conduits include flexible conduit portions connecting to the terminals.

The invention will be illustrated by the following description of a preferred embodiment with reference to the accompanying drawings in which:

Figure 1 is a schematic view of an air treatment system according to the invention including a fluid flow control valve incorporated in an air distribution terminal;

Figure 2 is an expanded view of the fluid flow control valve of the air distribution terminal of Fig. 1;

Figure 3 is a schematic elevation of an air distribution terminal incorporating a second embodiment of valve according to the invention;

Figure 4 is a exploded view of the components of the valve of Fig. 3;

Figure 5 is a plan view of a distribution terminal incorporating a third embodiment of a valve according to the invention; and valve.

Figure 6 is an plan view of the valve of Fig. 5.

As shown in Fig. 1, an air treatment system comprises an air blower such as a centrifugal fan (2) for drawing air to be treated from outside a wall (1) demarcating the space within which the air is to be treated. Wall (1) is therefore typically an exterior wall of a building. Air is directed by the blower (2) through an air treatment means (3) such as an air heater or an air cooler. From the air treatment means (3) the air is directed through a duct (4) to a primary air duct (14) serving air distribution terminals. Each terminal is connected to the respective primary air duct (4) by a flexible duct (15). Each terminal comprises a housing (12) defining an air inlet (8) for drawing air from a room or other space in which the air is to be treated, an air blower (11) in the form of an axial fan in this instance within the housing (12) for drawing air into the inlet (8) and an outlet duct (13) having an outlet into the space in which the air is to be treated.

At the end of the housing remote from the outlet is an inlet for treated air connected to the flexible duct (15). The inlet for treated air comprises a conduit (16) having an open end in which is received a perforate tube (5) closed at its downstream end by an end plate (18). The perforate tube (5) is provided uniformly along its length with perforations (19) and therefore provides a wall member through which air passing through the conduit (16) may escape into the housing (12) upstream of the inlet (8).

An annular sleeve (20), for instance a nylon sleeve, seals the tube (5) to the interior of the conduit (16) in which it slides. A rod (21) connected to end plate (18) connected to a linear actuator (6). Alternatively, rod (21) is articulted to an actuator arm (7) which is in turn connected at one end to a rotary actuator (6a).

Downstream of the inlet (8) but upstream of the fan (11) is a mixing zone (10) demarcated by a perforate plate (9) at its upstream end. Plate (9) is particularly of use in terminals having a cross section which is very wide compared to its height and serves to ensure good mixing of air entering the mixing zone (10).

In use, the fan (11) draws air from the space or room in which the air is to be treated through inlet (8) and into the housing (12). At the same time, treated, e.g. heated, air passes at a relatively high velocity through the ducts (4, 14 and 15) and is released through the perforate tube (5) at a rate depending upon the amount of the tube (5) extending from the conduit (16). This treated air mixes with the air drawn in through inlet (8) in the mixing zone (10) and is expelled back into the space through outlet duct (13).

The extent to which the foraminous or perforate tube (5) extends from the outlet conduit (16) of the treated air ducts depends on the setting of the actuator (6). This may be linked to one of a variety of means for controlling the setting of the position of the tube (5).

The actuator (6) may be linked to a manually operated control used to fix the position of the tube (5) so that the whole system, incorporating a number of terminal units (12), is in balance and provides the correct degree of heating or cooling from each terminal. Alternatively or additionally, the actuator (6) may be linked to a thermostat or other means for monitoring some condition of the air in the space to be treated to provide some degree of movement of the tube (5) to increase or decrease the amount of treated air allowed into the housing (12) in response to condi-

tions in the space or room. The flow of air through the housing (12) as a whole will be substantially constant but depending on the position of the foraminous tube (5), more or less of this air will be constituted by air drawn from the treated air ducts (4, 14 and 15).

Whereas the position of the foraminous tube (5) may be completely under the control of a thermostat acting through actuator (6) or may be entirely dictated by a manual control acting through actuator (6), it is possible to mix these functions so that a manual control dictates a base position for the tube (5) which is modified by a thermostat or such that the position of the tube (5) is controlled by a thermostat within a range dictated by a manual control.

Advantages of the system described above are that the pressure which is inherent in the high velocity duct (14) is absorbed by the perforated tube. Likewise the velocity of the air escaping from the foraminous tube is greatly reduced. The air leaving the perforated tube has substantially no excess pressure or velocity. Accordingly, air noise and air turbulence is minimal. It will be appreciated that whatever the position of the tube (5), air escaping from the interior to the exterior passes through each perforation (19) with substantially the same pressure drop and accordingly substantially the same velocity. This is in contrast to the situation in the controller taught in the specification of Daugherty referred to above. There is accordingly no tendency to increased noise as the tube (5) is moved further into the conduit (16). The perforated tube (5) allows control over the flow from the duct (14) from full air flow to zero air flow and the rate of flow of air from the duct (14) into the housing (12) is linearly proportional to the displacement of the tube (5) from the end of the conduit (16). The maximum rate of flow from the tube (5) into the housing (12) is easily selected by an appropriate choice of the specific free area provided by the perforations in the tube (5). All this provides a very accurate control over the flow of the high velocity air into the housing (12).

Setting up a high velocity air distribution system comprising a series of many outlets has in the past provided extremely difficult and adding subsequent outlets can prove to be impossible in some systems because of the imbalances created throughout the system by any modifications. By resetting the perforated tube described above to increase or reduce the free area, the starting point or base position of the tube or tubes can take account of the revised system pressures. If pressure changes to be made are drastic, then a perforated plate of revised net free area can be inserted into each terminal and the position of the tube may be varied as a fine control. By this means, the system according to the invention is capable of ready modification.

Fig. 3 shows a distribution terminal incorporating a further embodiment of a valve according to the invention. As shown in Fig. 3, a distribution terminal 30 has an inlet for primary air 31 leading through a control valve 32 to the interior of the distribution terminal. Inlets 33 for air drawn from the room containing the terminal are provided on a front face of the terminal on either side of an outlet for air drawn into the terminal from the room mixed with air from the primary air inlet 31. This secondary air outlet may be formed by a grill 34 behind which is positioned a centrifugal blower 35 of a crossflow or tangential type driven by a motor 36. As best seen in Fig. 4, the valve comprises an outer cylindrical sheet metal wall member 37 having a hemicylindrical surface portion 38 provided with a multitude of small circular perforations. Portion 38 is disposed between two circular end bands 39 which are not perforated. Within the cylindrical wall member 37 is received a generally cylindrical shutter 40 having a cut away portion forming an aperture 41 generally corresponding in size to the portion 28 containing the perforations in the cylindrical wall members 37. Gaskets (not shown) form a seal between the wall member and the cylindrical member at each end. Radially directed arms 42 meet in the centre of each end face of the cylindrical member 40 at a bushing 43 in which is received a drive shaft 44 mounted to an end cap 45 which on its outer surface bears an electric motor 46 connected to the rod 44 for rotation thereof. Rotation of the rod 44 causes rotation of the cylindrical shutter 40 within the cylinder 37 causing the aperture 41 to coincide to a greater or lesser extent with the perforate portion 38 of the member 37. Electric motor 46 is connected to a thermostatic control which adjusts the position of the cylindrical shutter 40 in response to room temperature. In a modification of what is shown in Figs. 3 and 4, motor 46 may be replaced by a manually operable control to allow presetting of the position of the shutter 40 according to the expected heat demands for the particular terminal.

As in the case of the embodiment described with reference to Figs. 1 and 2, the static pressure in the primary air distribution ducts leading to the inlet 31 to the terminal produces a flow through the apertures in the member 37 proportional to the exposed area of the portion 38 containing the perforations. In normal use, the pressure drop across the perforate barrier is essentially the whole of the inlet pressure so that no static pressure is developed within the distribution terminal as a result of primary air flow. The unit therefore operates in a quite manner with accurate control of the flow of treated air through the primary air circuit.

The distribution terminal shown in Figs. 3

and 4 is of the kind likely to be suitable for residental systems. A distribution terminal more suited to larger installations, for instance, commerical installations, is shown in Figs. 5 and 6. As shown in Fig. 5, a distribution terminal 50 comprising an inlet 51 for primary treated air to a control valve 52. Air from the room enters the distribution terminal from below through an inlet 53 and mixes with primary air passing out of the control valve 52 in a mixing chamber 54 and is drawn from the mixing chamber 54 by a centrifugal blower 55 in an inline configuration and directed out of the terminal through exits 56. The control valve 52 comprises a generally T-shaped housing, the inlet 51 constituting the upright of the T. The cross member of the T is formed by a cylindrical closed-ended tubular member 57 having adjacent each closed end a cut away window covered by a perforated plate 58. Each window extends around approximately half of the circumference of the tube 57 and extends inwardly from adjacent the respective end to a line continuing the base of the T formed by the inlet 51.

Within the tubular member 57 a rotatable shutter is provided mounted for rotation by a valve motor 59 provided on one end of the tube 57. The rotatable shutter 60 is divided into two parts, one received adjacent each of the perforated plates 58. Each part of the shutter 60 is linked by a central drive shaft (not shown) connected to the motor 59. Each of the two parts of the shutter 60 is formed as a cylindrical tube having a window therein corresponding in size and shape to the perforated plate 58 so that the shutter 60 is rotatable so that the perforated plate 58 is entirely closed by an underlying, non-windowed portion of the shutter 60 and is also rotatable to a position in which the perforated plate 58 is fully open for fluid flow therethrough and is coincident with the aperture formed in the respective part of the shutter 60.

It can be seen that the terminal designs described with references to Figs. 3 to 6 share the advantages described above in connection with Figs. 1 and 2. They are however more compact and enable the use of a rotary rather than a linear form of actuator.

Whilst the invention has been described with reference to characteristics of the specific embodiments illustrated, many modifications and variations are possible within the scope of the invention.

CLAIMS

1. A fluid control valve comprising means defining a flow path for fluid, a variable flow restrictor in said flow path comprising a wall member bounding a portion of said conduit, and having flow passages therethrough, means for at least substantially closing a portion of said wall member against fluid flow therethrough, means for producing relative movement between said wall member and said closure means to vary the area of said wall member exposed for fluid flow therethrough, the size of the flow passages through said wall member being such that there is at least one inlet pressure at which the valve with at least a substantial portion of the wall member exposed for fluid flow will produce a pressure drop substantially equivalent to the inlet pressure.

2. A valve as claimed in Claim 1, wherein said valve will produce said pressure drop at inlet pressures above 1495 Pa (6 inches water gauge).

3. A valve as claimed in Claim 2, wherein said valve will produce said pressure drop at inlet pressures above 498 Pa (2 inches water gauge).

4. A valve as claimed in Claim 3, wherein said valve will produce said pressure drop at inlet pressures above 62 Pa (0.25 inches water gauge).

5. A valve as claimed in Claim 1, wherein the flow passages through said wall member each have a cross-sectional area not exceeding 0.7 sq. cm.

6. A valve as claimed in Claim 1, wherein the said flow passages each have a cross-sectional area of not exceeding 0.16 sq. cm.

7. A valve as claimed in any one of Claims 1 to 6, wherein said wall member is a foraminous or perforate tube telescopically movable to extend from an outlet of the said flow path by a greater or lesser extent, said tube having a closure or flow restriction downstream of said outlet.

8. A valve as claimed in Claim 7, wherein said tube has a closure downstream of said outlet.

9. A valve as claimed in Claim 8, wherein said tube has a closure at its downstream end.

10. A valve as claimed in any one of Claims 7 to 9, wherein said tube is uniformly foraminous or perforate along its length.

11. A valve as claimed in any one of Claims 7 to 10, further comprising actuator means adapted to move said tube telescopically in said outlet by a degree dependent on a signal provided to said actuator means.

12. A valve as claimed in Claim 11, further comprising means for generating a signal to cause said actuator to move said tube telescopically in said outlet.

13. A valve as claimed in any one of Claims 1 to 6, wherein the wall member has a first portion having said flow passages and a second portion without said flow passages, and the closure member is a shutter having an aperture therein, and the wall member and the shutter are mounted to be adjacent and rotatable with respect to one another so as to vary the amount of said first and second portions of the wall member aligned with the aperture in the shutter.

14. A valve as claimed in Claim 13, wherein said wall member and shutter are interfittingly generally cylindrical members.

15. A valve as claimed in Claim 14, wherein said wall member is disposed over said shutter.

16. A valve as claimed in any one of Claims 13 to 15, further comprising actuator means adapted to rotate the wall member and shutter with respect to one another.

17. A valve as claimed in Claim 16, further comprising means for generating a signal to cause said actuator to rotate said wall member and actuator with respect to one another.

18. A valve as claimed in Claim 12 or Claim 17, wherein said signal generating means is a thermostat or a manually operable control.

19. A valve substantially as hereinbefore described with reference to and as illustrated in Figs. 1 and 2, 3 and 4 or 5 and 6 of the accompanying drawings.

20. An air distribution terminal comprising a housing having at least one inlet for drawing in ambient air, at least one outlet for expelling air from the housing, and an inlet for treated air, said treated air inlet being provided with a valve as claimed in any preceding claim.

21. A terminal as claimed in Claim 20, including air blower means for expelling air from the housing through said at least one outlet.

22. A terminal as claimed in Claim 20 or Claim 21, wherein the housing has a cross-sectional area substantially in excess of the cross-sectional area of the flow path of said valve.

23. An air distribution terminal substantially as hereinbefore described with reference to and as illustrated in Figs. 1 and 2, 3 and 4 or 5 and 6 of the accompanying drawings.

24. An air treatment system comprising a plurality of terminals as claimed in any one of Claims 20 to 23, and air treatment apparatus including means for drawing in and treating air, and means for delivering treated air from said air treatment apparatus to the flow path of the flow control valve of each said terminal.

25. A system as claimed in Claim 24, wherein the means for delivering treated air is a system of conduits of a cross-sectional area substantially less than the cross-sectional area of the housing of each terminal.

26. A system as claimed in Claim 24 or Claim 25, wherein the said system of conduits include flexible conduit portions connecting to said terminals.

27. An air treatment system substantially as hereinbefore described with reference to and as illustrated in Figs. 1 and 2 or Fig. 1 as modified by Figs. 3 and 4 or Figs. 5 and 6 of the accompanying drawings.

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